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BIOLOGICAL OPINION FOR THE TRINITY RIVER DIVISION OF THE CENTRAL VALLEY PROJECT

Dr. Dylan Fraser

Assistant Professor
Department of Biology, Concordia University,
Montreal, Quebec, Canada

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EXECUTIVE SUMMARY

The Trinity River is part of the second largest river system in California. Historically, it was inhabited by large populations of anadromous fishes that supported commercial, recreational and native subsistence fisheries in the region. Over the past several decades, a number of human activities have negatively affected the habitat and productivity of these fish populations, particularly the construction of dams in the late 1950s. These dams formed the Trinity River Division of the Central Valley Project, and they were intended to store, divert, and distribute water for irrigation to the Sacramento River basin. The U.S. Bureau of Reclamation has proposed to carry out the operations of the Trinity River Division between 2010 and 2030.

The present review assesses the scientific information found within the draft biological opinion conducted by the National Marine Fisheries Service (NMFS) as it pertains to the potential effects of Reclamation's proposed operation of the Trinity River Division on federally listed coho salmon (*Oncorhynchus kisutch*) populations within the drainage (Southern Oregon Northern California Coast (SONCC) Evolutionarily Significant Unit). Based on their consultation, the principal conclusion of NMFS is that the Reclamation's proposed action is likely to (i) jeopardize the continued persistence of SONCC coho salmon, and (ii) destroy or at least adversely modify the species' critical habitat.

Overall, the draft biological opinion uses much of the best scientific information available to reach these conclusions. For instance, the draft biological opinion is effective at considering the effects of the project on the habitat of listed coho salmon, and it adequately utilizes the concepts of viable salmonid populations and intraspecific population structure when assessing the present and future extinction risk of listed populations. The draft biological opinion also does an admirable job of incorporating and utilizing much of latest scientific information on climate change into the analysis of impacts from the project through the year 2030. However, the draft biological opinion could better incorporate and utilize more of the latest scientific information when considering the effects of hatchery fish on listed fish. Specifically, it is recommended that more discussion be included in the document regarding (i) the uncertainties surrounding studies that have found reduced fitness in hatchery fish relative to wild fish, and (ii) how future hatchery practices through the year 2030 could reduce the fitness impacts of stocking hatchery fish into the Trinity drainage. In addition, the consultation may benefit from further consideration of the likely synergistic effects that the Proposed Action and future climate warming will have on the phenology of listed coho salmon throughout the entire lifecycle. Lastly, throughout the document, further clarification is needed to distinguish between the loss or reduction of adaptive genetic variation versus the loss or reduction of standing genetic diversity *per se*, and whether or not references are being made to the within- or between-population component of genetic diversity.

SUMMARY OF FINDINGS FOR EACH TERM OF REFERENCE

Does the draft biological opinion incorporate and utilize the latest scientific information on climate change into the analysis of impacts from the project through the year 2030?

Given that future climate change will likely have dramatic hydrological consequences worldwide, it was imperative that the draft biological opinion consider information on climate change in its assessment of the impacts of the proposed diversion on listed coho salmon. To do so, the draft biological opinion uses a conservative approach towards assessing the impacts of climate change on SONCC coho salmon. This is based on a modeling approach wherein high risk scenarios for SONCC coho salmon are considered under the precautionary principle of biodiversity conservation (i.e. avoidance of extinction or increased extinction risk). Historical changes to temperature, precipitation and snowpack in the Trinity River system were firstly considered to model future changes to such environmental variables, based on similar climate information that was used in Reclamation (2008). The draft biological opinion particularly focuses on future climate scenarios of temperature warming with either less (drier) or more (wetter) precipitation. Indeed, these scenarios corresponded best with modeled trends in the Trinity River system (i.e. temperature increases of 0.1°C to 1°C per decade have been recorded in the past several decades). They were also conservative given expectations of climate warming in the Pacific Northwest (e.g. Battin et al. 2007). Future water temperatures, flows, storage levels at dams, and inflow rates were then forecasted in relation to the Proposed Action from these scenarios.

Because the Trinity River is a snowpack driven system, it may be especially vulnerable to climate change, including changes to juvenile habitat availability (summer and winter), and in the quality and extent of spawning and rearing habitats. The authors firstly project an annual temperature increase of 0 to 0.02°C up to 2030 in the Trinity system, possibly reaching as high as 0.04°C to 0.05°C per year if current trends persist. Snowpack, which has a direct influence on spring/summer flows and tributary thermal regimes−and hence coho salmon habitat−is expected to be lost at a rate of 0.5-1.0% per year in the Trinity system up to 2030. An earlier onset of the annual snowmelt runoff is also expected−in other words, the timing of inflow will also be altered with future climate warming. The authors then project that although the annual amount of precipitation will likely not change in the Trinity system, seasonal changes in precipitation will occur, with more snowfall/rainfall in the winter and less rainfall in the summer. All of these effects will in turn influence carryover storage and coldwater storage in the reservoirs behind Trinity and Lewiston dams. Thus, meeting future flow and temperature requirements under the proposed action may be challenging. Furthermore, the authors consider the potential consequences of projected sea level rises for the stability of coastal areas and estuarine areas linked to the Trinity system.

Overall, based on these considerations, the draft biological opinion reasonably suggests that future climate change will likely lead to a constriction of habitat for listed coho salmon in the Trinity system. Briefly, the thermal refuge habitat availability for juvenile coho will most likely be reduced in the summer, as summer water temperatures will increase to levels that in some cases will clearly be beyond the thermal tolerance range of coho salmon. The reduction in snowpack that will also occur with climate warming will further reduce thermal refuge habitat availability for juveniles. More precipitation in winters will also restrict coho salmon from spawning and rearing habitats in smaller order, higher gradient streams that they presently inhabit (and prefer), but this may also open up other areas for use as habitat (e.g. off-channel areas).

The authors of the draft biological opinion should be commended for their thorough consideration of a multitude of environmental variables that may be affected by climate warming within the Trinity system. Their modeling of potential climate projections incorporates and utilizes the best available information of future greenhouse gas emissions, temperature increases (e.g. Raupach et al. 2007) and precipitation changes, in relation to the area potentially affected by the proposed action (e.g. Bartholow 2005; Mote 2006; Luers et al. 2008; Van Kirk and Naman 2008). Given the inherent uncertainty regarding exact future environmental changes relating to climate change, they are also careful to consider all potential impacts on listed coho salmon, whether positive or negative for future persistence, in relation to different life history stages of the species (at least within freshwater: see below). In addition, because specific studies have not been conducted on Trinity system coho that examine the effects of climate change on coho salmon productivity, the authors importantly refer to other, relevant works that have done so on related species of salmon in the Pacific Northwest (e.g. Crozier et al. 2008; but see other related references in specific comments below). This discussion illustrates that the concern that regional climate change may impact the future productivity of listed coho is a reasonable one. Synergistic impacts of future climate change in relation to the Proposed Action are considered in a couple of parts of Section 7 (see the ToR relating to critical habitat of coho salmon).

One aspect of potential climate change effects on coho salmon that I thought could be better integrated into the draft biological opinion relates to changes to coho phenology. For instance, firstly consider that higher summer temperatures will probably translate into a delay in the autumnal temperature decline that in part influences spawning time in coho salmon (see Taylor 2008). Secondly, reduced snowmelt will result in an earlier timing of spring conditions (as stated in the draft, e.g. Stewart et al. 2004), as will warmer spring temperatures. Combined, that means that if coho begin to have to spawn later, their embryos incubating over the winter may then have to develop faster to emerge at a time that is conducive to survival and growth in the natural environment. Although it could be argued that higher winter temperatures might facilitate appropriate emergence times (developmental rates are of course affected by genetics but also by water temperature), it would appear that winter temperatures may not increase as much as summer temperatures in the Trinity system. Such an asynchrony in seasonal climate change effects could thus affect critical phenological events in the lifecycle of coho salmon. This could be extended to other life history stages as well in relation to changes in flow variability and water temperature, which might affect smolt or adult migration-timing (see specific comments and references below). Again, related points are sprinkled here and there throughout the document, but further discussion and cohesion of these points with a whole life-cycle perspective would be useful.

Another, related recommendation would be to further discuss the links between freshwater and ocean phases of the lifecycle and how changes to climate in either or both may influence listed coho salmon population productivity. Climate change impacts are most often considered in freshwater only in the document, but stresses incurred during the freshwater phase of the lifecycle may affect ocean survival (see specific comments and references below). Likewise, climate change in the ocean might affect upstream movements and/or the physiological or growth condition of coho salmon in the Trinity system and their ability to spawn successfully in freshwater (e.g. Scheuerell and Williams 2005).

A third recommendation relating to possible climate change effects on coho would be to perhaps clarify a bit more throughout that populations with a greater diversity of life history traits and genetic characteristics will have a greater ‘probability’ or ‘likelihood’ of adapting to climate change because it is more likely to express one or more successful traits that will allow it to persist. The use of the term ‘capacity’ assumes that more diversity means more adaptability, but it is having the right genetic diversity that matters, not the amount.

Finally, there are admittedly few studies that have examined the ability of coho salmon to adapt to environmental change. Nevertheless, have the authors considered, for example, the possibility that hatchery practices may inadvertently/directly favour fish that can better handle certain types of future environmental change in the Trinity system (e.g. higher thermal tolerance)?

Does the draft biological opinion incorporate and utilize the latest scientific information on the effects of hatchery fish on listed fish?

Throughout the draft biological opinion, the effects of hatchery fish on listed fish are discussed in terms of potential direct and indirect impacts that large releases of hatchery fish may have on the genetic diversity of natural coho salmon in the Trinity system (e.g. Sections 4.5.2., 4.11.5, 6.1.2, 6.3.12). Direct genetic impacts include the interbreeding of hatchery and natural fish, which may reduce the fitness of wild populations because of a number of genetic changes that are elicited in hatchery fish in their captive environments that reduce their overall capacity to survive and adapt in the wild. Direct genetic impacts may also include a reduction of genetic diversity that might occur in natural fish populations from interbreeding with hatchery fish. This can arise because hatchery fish usually far outnumber natural fish and have less genetic diversity than the total genetic diversity found within the natural populations with which they interbreed with. Indirect genetic impacts include competition of hatchery fish with wild fish, which may lead to displacement of natural fish, and ultimately increased mortality in the remaining natural fish. Indirect effects also include the superimposition of natural coho salmon redds by hatchery fish, which may result in a loss of substantial numbers of eggs. Hence, overall these indirect effects may result in a greater probability that genetic diversity is lost through random processes (e.g. genetic drift) as natural population size declines. These potential impacts are continuously referenced in the context of how adverse the proposed action may be for the future viability of listed coho salmon population units in the Trinity River system.

The draft biological opinion could better incorporate and utilize the latest scientific information on the effects of hatchery fish, some of which is not cited in the draft, when considering the impacts of the proposed action by Reclamation. This conclusion is primarily based on: (i) not enough consideration of the uncertainties surrounding studies that have found reduced fitness in hatchery fish relative to wild fish; (ii) a lack of consideration of how future hatchery practices through the year 2030 could reduce the fitness impacts of stocking hatchery fish into the Trinity River system; and (iii) some missing theoretical and empirical considerations that potentially weaken conclusions about hatchery fish reducing the genetic diversity found within remaining wild ('natural') fish in the Trinity River system. These and related concerns are discussed below, one-by-one, but it is important to note that they are not mutually-exclusive.

(i)The authors appropriately reference some recent studies that have clearly found reduced fitness in hatchery-propagated salmonid fishes in the Pacific Northwest (specifically, Araki et al. 2007, 2009). In some parts of the assessment of the proposed action, it appears that the authors use the reproductive success of hatchery fish in these studies to infer what the fitness performance of using hatchery fish will be in the Trinity River system (e.g. Section 7.2.1. October through April). On one hand, this is acceptable because very few studies have lifetime success estimates for hatchery and wild fish in the wild. And, as the authors point out, the Trinity River has a large proportion of hatchery fish relative to wild fish. On the other hand, for several biological reasons, the degree to which fitness may have been reduced in these studies on steelhead may not necessarily be the norm (Araki et al. 2008; see also Fraser 2008 for a critique; for coho salmon see: Ford et al. 2008). For instance, the time that hatchery fish spend in the hatchery differs between salmonid species, with steelhead commonly spending longer time periods. Hatchery steelhead may also have their growth rates artificially accelerated to reach smolt size at an earlier age, to a greater degree than other salmonids. Furthermore, the confidence intervals around the reduced fitness estimates of hatchery fish in these studies were often large, so the fitness of hatchery fish might not necessarily have been as low. This makes extrapolation to the Trinity system more tenuous.

It is recommended that careful consideration be given to these caveats in the context of the potential severity of the proposed action. This should include a consideration of what aspects of the biology of coho salmon, and coho hatchery propagation, may make the species more or less susceptible to changes in fitness from hatchery manipulations (relative to say, steelhead trout which have been most studied in this context to date).

(ii) Hatchery fish, even from locally-derived adult broodstocks (as is the case in the Trinity River), clearly can have reduced fitness relative to wild fish through domestication selection. However, to date, hatchery-wild comparisons have often involved cases where there was little attempt by hatchery managers and workers to reduce domestication selection in the hatchery and hence, to improve the fitness of hatchery fish relative to wild fish following their release into the wild. Historically, of course, domestication selection was not something that was considered in hatchery practices. Today, however, a large body of theoretical work has described means by which to maintain fitness (and genetic diversity) in captive environments such as hatcheries (Frankham 2008; Fraser 2008, references therein). Admittedly, these theoretical treatments are only now getting empirical attention, but the point is that there are simple procedures that hatcheries can apply to improve the chances that hatchery fish will survive upon release into the wild, and to maintain the genetic characteristics of the wild population. Many of these procedures are being implemented in captive breeding programs of severely endangered salmon populations (O'Reilly and Doyle 2007; Fraser 2008, references therein).

The significance of these points for the biological opinion is that there is no consideration in the document of the potential for the proposed action to reduce its impacts by implementing a number of procedures for reducing domestication selection in Trinity River hatcheries. If such procedures are not being implemented or will not be implemented in Trinity River hatcheries from 2009-2030, then this could be used to strengthen the argument that the effects of repeated hatchery inputs will likely reduce the fitness and probability of persistence of the listed coho population units. If, however, the proposed action does implement such procedures, then the severity of its impacts in the context of large hatchery releases might not necessarily be as high. More discussion of either case is necessary in the document.

(iii) Repeatedly throughout the draft document, it is viewed that releases of hatchery fish will result in a reduction in the genetic diversity of the 'natural' species. The concern is that this will reduce the adaptability and probability of persistence of the natural species if there is future environmental change. This is theoretically possible under certain conditions (Frankham 2005), but little if any empirical work has examined whether or not this may actually apply to salmonid fishes. Most research to date has been limited to the use of neutral genetic markers. Some research finds evidence for (neutral) genetic homogenization of wild populations following extensive mixing with hatchery salmonids, including in coho salmon (Eldridge and Naish 2007), while other studies do not show any evidence that stocking has affected population genetic structure *per se* via homogenization (Hansen et al. 2009).

If we consider the *amount* of genetic diversity in hatchery vs. wild fish in a situation such as the Trinity River, it is entirely plausible that the opposite is true – that is, hatchery fish far outnumber natural fish, so much so that hatchery fish might have higher levels of genetic diversity than the few remaining natural fish (within populations). In fact, straying could actually generate more genetic diversity within populations if hatchery-wild interbreeding occurs. If we consider the *nature* of the genetic diversity, many hatchery fish of course might not have the *right* diversity (their phenotypes would be maladapted) relative to the natural fish. It is difficult to envision how this would still result in a reduction of genetic diversity per se, unless again the hatchery generates a very large number of fish from a very small number of effective breeders, or there is some swamping of the natural gene pool through interbreeding with hatchery fish, or one has many, genetically similar hatchery fish mixing with many genetically-divergent natural fish (reduction in between-population diversity). Numbers of breeders in salmonid hatcheries can vary widely (Fraser 2008), but there is no quantitative data presented in the document to suggest that hatchery fish have lower genetic diversity than natural fish in the Trinity system. Alternatively, hatchery fish could lower genetic diversity indirectly via competitive interactions if they reduce the effective size of natural fish (Waples et al. 2007), although I am not aware of any empirical evidence for this possibility, as yet.

It is recommended that the authors clarify throughout the document such potential direct and indirect genetic consequences of hatchery-wild interactions when referring to the loss of 'genetic diversity'. They should pay particular attention to distinguishing between the loss or reduction of adaptive genetic variation versus the loss or reduction of standing genetic diversity per se, and whether or not they are referring to the within- or between-population component of genetic diversity.

Other - When considering that hatchery fish have reduced fitness relative to natural fish in the Trinity system and its impacts in relation to the proposed action, the authors might also wish to briefly comment somewhere that they have assumed that the rate to which fitness is lost (e.g. the number of recruits per spawner) may not be constant over time between 2009 and 2030. It might actually be worse initially and then taper off (Araki et al. 2008).

As a last, related comment, some discussion would be useful as to why hatchery supplementation is unlikely to offset survival reductions associated with the proposed project. For instance, reduced fitness in hatchery fish or hatchery-wild hybrids implies reduced population growth, but it could be argued that the hatcheries might just release more fish to compensate for any selective losses. Under this scenario, the population units could still be argued to be viable from a demographic context. Of course, this continual input of maladapted hatchery fish would potentially affect other viability parameters such as population diversity as is suggested in the draft. Presumably, 'demographic' vs. 'evolutionary' axes of viability are weighted equally by NMFS when assessing overall extinction risk.

Does the draft biological opinion utilize the concepts of viable salmonid populations and the population structure of listed coho salmon?

The draft biological opinion does a very good job of utilizing the concepts of viable salmonid populations (VSP) and the population structure of listed coho salmon when considering the likelihood that the proposed action will affect both the survival and recovery of coho salmon in the Trinity system. The concept of VSPs is considered in relation to McElrany et al.'s (2000) four parameters of abundance, population growth rate, population spatial structure, and genetic diversity, as these all relate to extinction risk. Specific application of the VSP concept to Southern Oregon Northern California Coast (SONCC) coho salmon is considered in sections 4.6 to 4.11.5 in relation to Williams et al. (2006, 2007, 2008; note, the 2006 reference is missing from the draft biological opinion). Generally speaking, small populations are at a higher risk of extinction than larger ones, all else being equal and population growth rate may suggest the ability of populations to replace themselves (McElhany *et al*. 2000). Spatial structuring can infer habitat quality and thus viability over time periods, and genetic diversity provides the raw material for surviving long-term environmental change (McElhany *et al*. 2000). I now summarize the draft biological opinion's conclusions regarding the impacts of the proposed action in relation to each of the four parameters of extinction risk described above, and the four coho population units in the Trinity River system (Upper Trinity, Lower Trinity, South Fork Trinity, Lower Klamath River).

Abundance-As of 2009, most SONCC coho populations had declined well below historical levels, and none of the seven population diversity strata outlined by Williams et al. fulfill the low risk abundance threshold. There is no abundance data for Upper Trinity River or Lower Trinity River, but hatchery fish make up a large proportion of returning adult spawners and the number of natural spawners likely does not fulfill the criteria of Williams et al. (2006, 2007). Abundance data on the South Fork Trinity River and Lower Klamath River units provides evidence that these units do not meet the low risk abundance threshold and each appears lowers than the depensation threshold.

Between the years 2009-2030 of the proposed action, the draft biological opinion suggests that the abundance of Upper Trinity River, Lower Trinity River and South Fork Trinity River coho would remain high or be slightly reduced relative to 2009 numbers because of increased hatchery inputs, but this will also result in a continued reduction of naturally-produced fish over time. Abundance of Lower Klamath River coho would be reduced from predominantly increased ecological interactions with hatchery fish.

Population growth rate-As of 2009, several SONCC populations have shown recent declines in abundance (with the exception of one population), implying reduced or negative population growth rate. There is evidence that the numbers of recruits-per-spawner has declined in Upper Trinity River, a negative population growth rate is implied for Lower Trinity River based on historical declines. Reductions in numbers of adult spawners in the South Fork Trinity River and Lower Klamath River imply that these units are experiencing reduced (negative) population growth as well.

Between the years 2009-2030 of the proposed action, the draft biological opinion suggests that the implied, negative population growth rate of natural coho in all four population units as of 2009 will continue to be exacerbated due to a loss of habitat and more intensive hatchery influence.

Population spatial structure-As of 2009, the spatial structure of SONCC may have been reduced because coho no longer occupy some of their historical habitats, but coho are represented in all major river basins. Particularly within Upper Trinity River and South Fork Trinity River units, coho salmon are found in only a fraction of the habitats they used to inhabit. The loss of between-population structure through hatchery-wild mixing (and hatchery strays) is likely in three of four units (Upper Trinity, Lower Trinity, South Fork Trinity).

Between the years 2009-2030 of the proposed action, the draft biological opinion suggests that the spatial structure in Upper Trinity due to reductions in flow variability, reduction in cover and simplified habitat, ecological interactions with hatchery fish, and mixing with hatchery fish. Climate warming is also anticipated to reduce spatial structure in the Lower Trinity River unit as it will make tributaries uninhabitable to coho salmon due to reductions in snowpack and limited availability of cold water habitat. Spatial structure would not be reduced in the South Fork Trinity River and Lower Klamath River population units.

Genetic diversity-As of 2009, some diversity may have been lost in the SONCC through extensive mixing with hatchery fish (whether from local hatchery strains, or out-of-basin hatchery strains). The loss of some populations, based on their absence in previously occupied habitats also implies that some diversity has been lost. Particularly within Upper Trinity River and South Fork Trinity River units, coho salmon are found in only a fraction of the habitats they used to inhabit. The loss of between-population diversity through hatchery-wild mixing (and hatchery strays) is likely in three of four units (Upper Trinity, Lower Trinity, South Fork Trinity).

Between the years 2009-2030 of the proposed action, the draft biological opinion suggests that the spatial structure in Upper Trinity due to reductions in flow variability, reduction in cover and simplified habitat, ecological interactions with hatchery fish, and mixing with hatchery fish. Reduced genetic and or life history diversity from interactions with hatchery fish is also implicated in Lower Trinity River and South Fork Trinity River units. It is suggested that there would be no change in genetic diversity within the Lower Klamath River population unit because rates of hatchery straying are low, but ecological interactions with hatchery fish could affect some life history diversity.

Collective conclusion about risk of extinction-As of 2009, the draft biological opinion provides ample justification based on scientifically sound assessments of extinction risk that SONCC coho salmon will likely become endangered in the foreseeable future and that this ESU is currently not viable. All units are currently not viable and at a moderate risk of extinction, but for different reasons depending on the four parameters of viability. More natural reproduction (less hatchery influence) and greater representation of coho salmon across the watershed would appear to be important for the future persistence of the species in the Upper Trinity River and South Fork

Trinity River units. Increasing abundance and growth rate has been deemed of utmost importance in Lower Trinity River.

Between the years 2009-2030 of the proposed action, and based on climate, habitat shift and hatchery input projections, an increased probability of extinction is expected in three of four population units (Upper Trinity, Lower Trinity, South Fork Trinity) , but for slightly different reasons in relation to the four viability parameters.

I have three recommendations for the authors based on the information and conclusions provided in the draft biological opinion. First, much of the interpretation of the effects of hatchery fish in the future is based on a few empirical works that have evaluated the lifetime success of hatchery vs. wild fish in the wild. However, as discussed in the previous ToR, there are a number of uncertainties about these works that must be considered when assessing the future impacts of hatchery coho on listed coho in the present document (see above).

Second, in 'diversity' and 'population spatial structure' sections for each population unit, it is often assumed that low abundance of adult coho spawners means that genetic diversity has been reduced. This is of course theoretically plausible, but there is remarkably little, if any, empirical support that smaller populations of salmonids may have a reduced capacity to respond to environmental change relative to larger ones. Smaller populations of salmon may show reduced genetic diversity at neutral genetic diversity markers such as microsatellites, but whether this translates into a reduction in quantitative genetic variation (the stuff that arguably matters for conservation) has not been assessed – quantitative and neutral measures of genetic diversity are often uncorrelated (e.g. Reed and Frankham 2001; see also Willi et al. 2006).

Third, there are aspects of the biology of coho salmon that might act as natural 'buffers' against the loss or reduction of genetic diversity at lower abundance, including: (i) low rates of natural straying; (ii) alternative reproductive tactics in males (males mature at different ages, so cohorts mix); and (iii) multiple cohorts can contribute to an annual spawning run. At least in other salmon species with analogous life histories, these aspects appear to act as such buffers (e.g. Araki et al. 2007c; Fraser et al. 2007). Some discussion of these possibilities would be useful in the document, towards a more thorough consideration of the relationship between population abundance, life history, and the amount of genetic diversity.

Does the draft biological opinion consider the effects of the project on the habitat of listed coho salmon?

The draft biological opinion is thorough in considering the effects of the project on the habitat of Trinity River coho salmon. The draft is firstly careful to summarize existing critical habitat for SONCC coho salmon, including the factors that affect this critical habitat, such as timber harvest, roads, agricultural practices, urban and industrial development, dams and diversions, fish passage barriers, channelization and diking, mining, watershed restoration, and climate change (Sections 5.1 to 5.2.10; 6.3.1 to 6.3.15). The draft biological opinion is then careful to consider the current state of critical habitat in the SONCC ESU, in relation to the essential habitat types that are necessary to support the different life history stages of the species: juvenile summer and winter rearing areas, juvenile migration corridors, adult migration corridors, and spawning areas (Sections 5.3 to 5.3.5; 6.2.1 to 6.2.3, 6.3.11). As of 2009, habitat in all of these different life stages has been affected at varying degrees by several of the following human-induced environmental changes, particularly the dam and dam diversions: low flows, lack of flow variability, changes to natural, unimpaired flow regimes, sedimentation (e.g. of salmon redds), stream habitat simplification, corresponding high water temperatures related to altered flows, low dissolved oxygen levels, excessive run-off from storms, elimination of bedload transport, and prevented access (blockage) to upstream spawning areas.

A salient feature from the consideration of the current state of critical habitat in the SONCC ESU is that it has already been impaired in most streams and often lacks key features and elements needed for ongoing survival of coho salmon. For example, in the Upper Trinity River, juvenile summer habitat appears to be highly impacted by high summer temperatures, low flows, and a lack of thermal refugia. Disease effects are thought to strongly impact juveniles in their migration corridors, as do low flows which may hinder movements and migration timing (see also Lower Trinity and Lower Klamath). Adult migration corridors are likely affected by the lack of flow variability in the system, which influences the timing of upstream migration in Upper and Lower Trinity River population units. Degradation of spawning and rearing habitats, such as increased sedimentation, is implicated in population declines and reduced juvenile recruitment in all three population units where habitat changes will occur under the proposed action (Upper Trinity, Lower Trinity, Lower Klamath).

Based on what is known of the current state of critical habitat in the Trinity River system, and the biology of coho salmon both in general and within the Trinity system (Section 6.1.1), the draft biological opinion then considers what hydrologic and temperature effects the proposed action will have on critical habitat of Trinity River system coho salmon between the years 2009-2030 (Section 7). These effects are considered very comprehensively. Indeed, they are considered for each population unit, they are separated by different times of the year (October through April, May through July, August through September), they are separated by habitats of different life history stages of coho salmon (juvenile summer and winter rearing areas, juvenile migration corridor, adult migration corridor, and spawning areas), and they are considered under five different hydrologic/temperature conditions that may arise with future climate warming (extremely wet, wet, normal, dry, critically dry), but predominantly two scenarios (warming and either more or less precipitation) as these are most likely for the Trinity River region.

The comprehensive evaluation of future hydrologic and temperature effects of the Proposed Action reveals the following trends. First, declines of coho salmon in the Upper Trinity River will likely continue because several life history stages will be severely impacted by the Proposed Action, predominantly due to higher water temperatures, very low water flows under most conditions but especially in dry or critically dry years, shrinkage of habitat, increased competition with hatchery fish (due to habitat reduction), and reduced flow variability. Second, declines of coho salmon in the Lower Trinity River may continue in the future because the Proposed Action will result in increased hatchery inputs. These hatchery fish will likely compete with remaining natural fish for remaining thermal refugia (increased summer temperatures under the Proposed Action would reduce critical juvenile habitat, but not necessarily later on towards the autumn), and thus may have detrimental impacts on natural coho survival. Changes in flow variability with the Proposed Action are thought to not have as severe impacts in the Lower Trinity as in the Upper Trinity, except for some dry water year types. The Lower Klamath River was not discussed in terms of effects on critical habitat by the Proposed Action, because it falls within the boundaries of tribal lands.

Importantly, the draft biological opinion also considers how ongoing habitat restoration efforts in the Trinity River might help to mitigate future habitat changes/losses associated with the Proposed Action (e.g. Sections 5.2.9, 6.2 'Habitat baseline'). However, improvement of the design of road culverts and other road crossings, or spawning gravel augmentation, for example, does not appear likely to compensate for all changes and/or loss of habitat associated with future dam diversion and/or future climate change. For example, the time recovered for a complete recovery of coho salmon in many Trinity streams is expected to take several more decades than the duration of the Proposed Action.

Does the biological opinion represent the best scientific information available?

For the most part, I found that the draft biological opinion uses the best scientific information available to assess the overall impacts of the Proposed Action on listed coho salmon. This is particularly true for the sections of the document that consider: (i) the local history of the Trinity River system in relation to environmental change and human activities; (ii) climate change modeling; (iii) climate change into the analysis of impacts from the project through the year 2030; (iv) the concepts of viable salmonid populations and population structure in relation to listed coho salmon; (v) the current status of the different coho population units; (vi) the status of the critical habitat as of 2009 for the different population units of coho salmon; and (vii) the environmental baseline in terms of coho salmon life history, habitat and the factors affecting coho salmon habitat. Importantly, these sections provide a well-balanced account of the potential impacts on coho salmon that might arise from the Proposed Action.

Based on my comments and recommendations for each of the first four terms of references, a first overall recommendation would be to especially bolster the scientific information content of the section on the effects of hatchery fish on listed fish (and related discussions of the impacts of hatchery fish throughout the document). This should include greater consideration of (i) the uncertainties surrounding studies that have found reduced fitness in hatchery fish relative to wild fish, (ii) how future hatchery practices through the year 2030 could reduce the fitness impacts of stocking hatchery fish into the Trinity River system; and (iii) theoretical and empirical considerations that potentially weaken conclusions about hatchery fish reducing the genetic diversity found within remaining wild ('natural') fish in the Trinity River system.

Sections dealing with climate change impacts could also benefit from the addition of some other information and references. Specifically, more discussion of the changes to coho phenology across the entire lifecycle that may arise in the face of future climate change and with the Proposed Action would be useful. So too would more consideration of the inseparable links between freshwater and ocean phases of the coho life cycle, and how environmental and habitat changes in one phase might influence the success of coho salmon in the other, and more generally, the productivity of listed coho salmon.

In the subsequent section, I include a number of specific comments relating to various sections of the draft biological opinion. The accompanying bibliography with an additional >40 peer-reviewed articles not cited in the draft document is intended to help improve the overall scientific information content and clarity of different sections, in accordance with the terms of reference and the recommendations highlighted above.

Additional, specific comments for various sections of the draft biological opinion

General comment. There are, unavoidably, a large number of acronyms used throughout the document. Perhaps a glossary for these acronyms somewhere in the document would be useful.

Page 2-1. Over how many years are these average rainfall and snowfall estimates based on, and have these changed significantly over time?

Page 2-2. Inflow averages are based on data from 1963 to 2008. This assumes that the water volume of inflows entering Trinity and Lewiston Reservoirs have been at this level over the entire period, but what if there is a trend for lower inflow rates now than in the past? If true, the 3% evaporation rate today would be underestimated substantially. Perhaps the % that evaporation makes up of the total inflow rate can be standardized based on the same time series of data as well (i.e. the same time period of years).

Page 2-4. Is the implicit assumption of future inflow rates being the same as from 1912 to 1994 an acceptable one for this region?

Page 2-6. What exactly is meant by the statement "Trinity River Hatchery has generally been successful at meeting release goals…."? How often are these goals met, and how often are they not met?

Page 3-9. Is there a reason why no critical habitat for coho salmon has been designated in the Klamath River portion of the action area?

Section 3.7.1. Unimpaired flows
I recognize that such assumptions are necessary. However, it would be useful here to briefly describe the implications of using unimpaired flows from Lewiston between 1912-1960 to describe the magnitude of hydrologic effects of the proposed action between 2009 and 2030. That is, while I recognize that the dam was constructed in 1960, there has been 50 years of potential climate change since this time.

Section 3.7.2. Climate change
There is a bit of redundancy in Trinity basin climate change information in this section. Also, is the Raupach et al. study specific to this region or elsewhere in the Pacific Northwest?

Second and third paragraphs. Specify where 'temperature' refers to 'water temperature ' vs. air temperature' throughout.

Second paragraph addition suggestion specific to salmon. Higher temperatures will likely mean a delay in the autumnal temperature decline that in part influences spawning time (Taylor 2008).

Could the time periods considered for unimpaired flows and the climate baseline data be standardized? Perhaps not – just that flow is interrelated with climate.

Section 4.4. ESU Status and Trends of SONCC Coho Salmon
It is not clear what the terms in quotations mean throughout this paragraph. Can the authors give an approximation of the years when referring to 'recently'? Also, in the context of hatchery vs. wild fish, it would be informative to define what 'hatchery' vs. 'wild' means and keep to same terms throughout the document. It is not clear what 'native' means relative to 'wild' or 'hatchery'. For example, is a 'native' fish one with no history of hatchery influence and whose parents had no hatchery influence, etc.? Or a fish that has lived in the wild for the entirety of its life, but whose parents were hatchery fish?, etc. I refer the authors to two recent papers which discuss the importance of distinguishing between these terms in the context of considering the potential impacts of hatchery fish on wild fish: Araki et al. (2008) and Fraser (2008).

Section 4.5.1. Disease and predation. The last sentence of this paragraph might be stronger with some references. References would also be useful for the following sentences: "*Normally, predators play an important role in the ecosystem, culling out unfit individuals, thereby strengthening the species as a whole*." and "*Without adequate avoidance habitat (e.g., deep pools and estuaries, and undercut banks) and adequate migration and rearing flows, predation may play a role in the reduction of some coho salmon populations."*

Section 4.5.2. Artificial Propogation.
The McGinnity et al. (2003) reference is often cited as evidence that hatchery salmon have reduced fitness relative to wild salmon, but this study compares the performance of artificially-selected farmed salmon to that of wild salmon. Domesticated strains of farmed salmon are not comparable to the average hatchery fish in most cases, unless there has been blatant intentional selection over successive generations (see Fraser 2008). I would suggest eliminating this reference to refer to 'hatchery' fish for the purposes of this document, and focus on more relevant studies such as those done by Araki et al. on west coast steelhead (2007a,b) or Carofinno et al. (2008) on introduced Great Lakes steelhead.

Some rewording would be useful in this section, as there also appears to be some conflation of terms. For example, the loss of fitness in hatchery-wild mixing from a loss of local adaptation is an actual type of outbreeding depression (environmentally-based, hybrids do not 'fit' the phenotypic optimum). Outbreeding depression can be also intrinsically based (loss of local adaptation and outbreeding depression are not necessarily two different phenomena).

Section 4.5.4. Climate change.
Please specify what you mean by *"Coho salmon are sensitive to rapid climate change because of their rigid life history"*. What is it about this life history that is more rigid than say other salmonid fishes? Smolt age? Run-timing? Size-at-age? Etc.? At least for embryonic or early-life history traits in coho salmon, I suggest that the authors refer to Beacham and Murray (1990) and Murray et al (1990).

Also, it may be useful to discuss that temperature changes with climate warming will not just be a concern from the standpoint of temperature tolerance (i.e. can juveniles survive the warmer temperatures?), but are also a concern from the standpoint of affecting the phenology of critical life history events (developmental rates to hatching, spawning time, smolt migration timing etc.).

Perhaps consider Stenseth and Mysterud (2002) and Crozier et al. (2008, salmon paper) for the context of the consequences of shifts in phenology relating to climate change.

Section 4.6. SONCC Coho salmon population viability
What is the justification that Williams et al. (2007) provide for the '50% of independent populations must be viable' criterion? Briefly explain.

Section 4.7. Population size
"As a result, the higher the proportion of hatchery-born spawners, the lower the overall productivity of the population, as demonstrated by Chilcote (2003)." Chilcote did find evidence for such a relationship, but this is only one study. Perhaps the authors can refer to Waples et al. (2007). This is arguably the most comprehensive study to date that has assessed whether or not hatchery fish contribute to the productivity of wild populations. This paper suggests that the relationship between hatchery influence and population productivity is not necessarily as clean cut as the Chilcote study, but it also points out that hatchery fish may not contribute a long-term demographic boost to populations.

Section 4.10. Diversity.
"NMFS concludes the current phenotypic diversity in this ESU is much reduced compared to historic levels, so by McElhany's (2000) criteria it is not currently viable in regards to the diversity VSP parameter." Can the authors clarify what 'not currently viable' means? And, perhaps 'diversity' at the beginning of the paragraph could be changed to refer to phenotypic, genetic, and life history to be more encompassing.

5.2.10. Climate change.
Last sentence – change 'that' to 'than'.

Third paragraph. Providing some references that such impacts are likely would be useful here, for example that fine sediment can suffocate eggs during rearing (e.g. Jensen et al. 2009).

Fourth paragraph. Some discussion of the literature on the temperature tolerance range of coho salmon, especially at juvenile stages, would be useful here. See Beacham and Murray (1990) and Murray et al. (1990) for early stages, Richter and Holmes (2005) for other stages. It would also appear that the Trinity River Flow Evaluation report of 1999 includes a Table with older studies on the actual thermal tolerance range of coho salmon. It would also be beneficial to provide some referencing based on climate model predictions from other works on salmonid fishes (including other species of Pacific salmonids), such as Crozier and Zabel (2006), Crozier et al. (2008).

5.3. Current condition of critical habitat at the ESU scale.
Suggest changing the wording to 'may be more susceptible to changes in the freshwater environment...'. It could be argued that it is not necessarily the length of time that each salmonid spends in freshwater that makes them more or less susceptible to climate change, but rather the magnitude of change that occurs in the kind of freshwater habitat that each species uses.

5.3.1. Juvenile summer and winter habitats.

Are there any data to illustrate the compromises in habitat suggested here, such as pH fluctuations, increases in invasive species, densities of stream invertebrates etc.? The list of compromises/changes is all very likely, but there is no quantitative information to provide any firm backing to these concerns.

5.3.2. Juvenile migration corridors
How does a juvenile migration corridor suffer from 'disease effects' in this region? Please briefly elaborate.

5.3.3. Adult migration corridors
Perhaps the authors can add in this section that increasing temperatures might increase stresses related to upstream migration before spawning. Higher temperatures in streams might metabolically require more energy reserves, for example (e.g. see Crozier et al. 2008).

6.1.1. Periodicity and life history
Outmigration 0+ - what other spawning habitats are more usually preferred by coho salmon? And what is different about the habitat near the hatchery in the Trinity system? This is not clear.

6.1.2. Risk of extinction.
Upper Trinity River population unit – Again, I suggest deleting any of the references in this section pertaining to domesticated (farmed) salmon and their interactions with wild salmon, as these do not typify general hatchery fish (Brannon et al. 2004; Fraser 2008). Also, it is not clear in this section what *"through genetic interactions on the spawning grounds"* means. Do the authors mean that interbreeding between hatchery and wild fish may lead to a reduction of fitness in progeny of such matings in the wild?

6.1.3. Population size.
This section might benefit from some discussion on the genetic consequences of small population size, rather than just the demographic ones (or environmental stochasticity as well). There is a wealth of literature now to suggest that genetic factors are likely implicated in the extinction process when populations become small (e.g. Frankham 2005). There is also considerable theoretical treatment of this subject as it pertains to salmonid fishes (e.g. Waples 1990, 2002; Fraser 2008).

Table 6.1. Does the CDFG (2008) document provide 95% confidence intervals for the run estimates? Or are these estimates based on a conversion from catch-per-unit-effort (e.g. with trap nets)?

In the viability summary, Upper Trinity – change that boosting the natural component of adult returns MAY help to increase genetic diversity in the population. I suggest this because there are ways in which genetic diversity can be increased with hatchery practices which might be more difficult to have happen in a natural setting (it is just that historically, hatcheries have not paid attention to this sort of thing: Fraser 2008).

In the viability summary, Lower Trinity – mixing with hatchery fish could reduce genetic diversity in wild fish, but I think what the authors really mean to say here is that hatchery-wild mixing could reduce local adaptation in wild fish by causing shifts in quantitative trait distributions (that have a genetic basis). Based on recent works (see e.g. Araki et al. 2008), this is likely to be more of an immediate concern to depleted wild populations than reduced genetic diversity through a homogenization effect *per se*.

Lower Klamath River, population unit- *'However, low numbers of spawners in certain years could result in low genetic diversity.'* Suggest changing to 'could result in a loss of genetic diversity because of small population size'.

6.3.2. Roads.
Grammar. *"where small tributary streams containing reaches with high or medium potential for coho salmon TO exist".*

6.3.8. Marine mammal predation.
"Predators play an important role in the ecosystem, culling out unfit individuals, thereby strengthening the species as a whole." Suggest re-wording – see above comments.

6.3.10. Climate change.
"By changing the fitness landscape of coho salmon and applying a new set of selection pressures,climate change will impact the diversity of SONCC coho populations through inherent plastic (i.e. non-genetic) and genetic evolutionary responses. The outcome of these responses will likely be a new life history and genetic structure since some life histories and genetic characteristics will be favored while others die out in the population due to the selection pressures against them. A population with a greater diversity of life history traits and genetic characteristics will have a greater capacity to adapt to climate change since it is more likely to express one or more successful traits that will allow it to persist."
Again, it would be useful to clarify if diversity is being considered in the context of the within-population level, or the between-population level. Assuming this reflects the within-population level -the point that larger populations are more viable and may be more likely to harbor the genetic diversity needed to respond to future climate change is a valid one. The authors could also add that larger populations, on average, should be more capable of more rapidly responding to faster rates of environmental change than smaller populations as well (Robertson 1960; Weber and Jiggins 1990). This is because selection has an easier time operating in larger populations than smaller ones, where genetic drift can overcome selection (Fraser 2008).

Page 78, last paragraph. Grammar. 'THOUGHT' to be highly adaptive to change.

'Because northern California and southern Oregon are near the southern end of the species' distribution, the effects of climate change on SONCC populations may be even more pronounced than what has been found for other coho populations.' The authors might want to refer to Mountain (2002), who also argues that fish species such as salmon (in this case Atlantic salmon) at the southern part of their species ranges may be especially harmed by future climate change.

Table 6-7. Grammar. 'CRITICALLY'.

6.3.12. Hatcheries.
Genetic impacts - *"Hatchery-reared coho likely produce eggs that are smaller than those that may have had less hatchery influence, and these smaller eggs are less likely than larger eggs to survive outside of the hatchery (Heath et al. 2003)."*
This is a possibility for any salmonid, but it is not as straightforward as written, and I suggest more care is needed in the interpretation of this pattern/study. The authors should recognize that the findings of the Heath et al. (2003) have been routinely questioned as to whether they truly reflect genetic changes given that genetic differences may have been confounded with rearing environment in their study (Fleming et al. 2003; Beacham 2003). Furthermore, larger eggs do not necessarily lead to greater survival than smaller eggs in salmonids (Einum and Fleming 2007, references therein), and to my understanding, only Einum & Fleming (1999) have effectively dealt with the issue of potentially confounding environmental and genetic influences when examining whether smaller or larger eggs may generate lower/higher fitness depending on environmental conditions.

It may also be useful to add in this section that, in addition to the evidence for hatchery fish to have reduced fitness even after just one generation of captive rearing, the overall literature suggests that the magnitude of this fitness loss will increase with increasing numbers of generations of hatchery influence (Fraser 2008).

Ecological impacts – Again, the review of Waples et al. (2007) might be informative to consider here because it assesses how hatchery influences may influence the productivity of wild populations.

Table 6-8, and text on hatchery supplementation procedures. Here again, could natural fish have had some hatchery ancestry, such as one or two generations back? In any event, it is clear that hatchery fish make up most of the annual spawning run. Nevertheless, attempts to reduce hatchery-'natural' gene flow may be complicated if some of the 'natural' fish returning had hatchery parents or grandparents.

7.2.1. October through April
In this section, it is repeated that the large releases of chinook salmon fry and rainbow trout fry may act as competitors for coho salmon. Because chinook and rainbow have always been natural competitors in this system presumably, is it not more concerning that the numbers of fry far outnumber the natural densities of these other species within the Trinity system?

Juvenile - *"NMFS assumes that coho salmon in the Trinity River have evolved life history strategies in direct response to the natural flow regime (Taylor 1991; Bunn and Arthington 2002; NRC 2004; Beechie et al. 2006)."*
The environmental change in the Trinity River system related to less variable flow (i.e. 'impaired' flow) since the inception of the dams brings up an interesting point and potential counter to this philosophy. It could be argued that sufficient time (several coho generations) has past such that coho salmon may have evolved to deal with the selective regimes brought on by damming. Rapid evolution over several generations has been documented in various salmonids, in cases where the rate of environmental change was great/fast (e.g. Hendry et al. 2000; Koskinen et al. 2002). It is thus plausible that coho salmon in the Trinity might actually be

negatively impacted by an unimpaired flow regime, if reversion back to an unimpaired flow regime occurs too quickly. In such a case, the Proposed action is not necessarily any more harmful than an unimpaired-variable flow regime, if demographically, viable numbers of coho can still survive in the system. Perhaps then, it is important to better re-stipulate and re-justify here why reversion back to a natural flow regime is also better for coho salmon even if they have adapted to flow regimes with damming over the past few decades (e.g. would life history diversity be increased? Would numbers of fish increase etc?). Good references considering these issues would be Angilletta et al. (2008) and Bisson et al. (2009).

Smolt – possible addition. If the Proposed Action increases travel time to the estuary, then another possible source of mortality might also occur later on in the life cycle after smolts leave the estuary, because phenology of critical life history events/stages would be altered/delayed. This might lead to reduced marine survivorship, or less time to accrue at sea, which might then affect age-at-maturation, and/or reproductive fitness in the returning adults upon reaching sexual maturity (Garcia de Leaniz et al. 2007).

Adult – *"The extremely low average recruit per spawner value of 0.24, well below the replacement level of 1, from 1997 to 2005 is probably good evidence of 7-99 this (Table 6-2)."* It must be more carefully worded throughout this paragraph that reduced fitness of hatchery fish *could* explain these patterns, rather than that this pattern *indicates* a likely reduction in fitness in the population. It can be equally argued that the reduced average recruit per spawner from 1997 to 2005 has an environmental basis, not a genetic one. As a result, to be more unbiased, it might be best to tone down a bit the conclusion *"Taken together, it is likely that fitness of the Upper Trinity River Population is low, and straying of this population into other populations likely reduces the fitness of the these populations."* As previously stated in earlier comments, there is sparse empirical support for the hypothesis that hatchery strays reduce fitness in surrounding populations around the focal population in which they are stocked. Not to say that this isn't a concern, but it is very difficult to demonstrate this in practice, and population genetic studies with neutral genetic markers cannot answer this question outright.

Finally, in the last paragraph, the McGinnity reference should be removed because it does not consider general hatchery fish, and its inclusion weakens the argument put forth (seventh generation domesticated farmed salmon most likely do not typify the average hatchery fish used for stocking in the Pacific Northwest). In addition, the authors should be aware that there are caveats with some of the studies they cite here on hatchery effects to wild populations. This consideration might improve how balanced the conclusions are here. The Reisenbichler study, for example, only found evidence of reduced fitness in hatchery-wild hybrid fish relative to wild fish in two of four streams studied (they actually performed better than wild fish in some cases). I recognize that this argument comes down to a half-glass full, half-glass empty situation, but it simply is not always clean cut that hatchery fish perform more poorly than wild fish according to such historical studies. Perhaps stick to referencing recent works only, and those that use only 'local' origin hatchery fish (detailed in Fraser 2008).

It is also not entirely clear why it is assumed that the reproductive success of coho in the Upper Salmon River has been reduced by 65% due to hatchery straying. If this value is based on the works of Araki, wouldn't the upper limit technically be 63%? Estimates of reproductive success in hatchery fish/hatchery ancestry fish in the Araki studies have large confidence intervals around them (Araki et al. 2007a,b). Have the authors considered using the range of values with 95% CI for their assessment? This applies to section 7.3.2. as well (Lower Trinity).

7.2.2. May through July.
Table 7.8. Title. Grammar. PROPOSED.

Juvenile summer rearing areas – see comment above regarding additional concerns of stocking large numbers of chinook salmon and rainbow trout.

7.2.4. Summary of effects.
Upper Trinity - The fact that coho spend more time in freshwater than chinook suggests that they might be more susceptible to environmental changes at this stage of the life cycle than chinook salmon. However, as the seasonal look of the Proposed Action's impacts illustrates, environmental changes likely vary dramatically with the season. Perhaps also include here that the coho are directly impacted by the time periods when the extent of environmental change brought on by the Proposed Action is at its greatest (relative to chinook).

Lower Trinity – Fry section. Grammar. BEGINNING.

Smolt section. Couldn't aggregations of hatchery smolts also attract the attention of predators at this stage, thereby increasing predation on coho smolts?

Lower Klamath River (and others) – couldn't returning adult hatchery fish also compete with natural coho on spawning grounds?

10.1. Impacts on population viability.
I guess it is beyond the study to provide what amount of discharge is necessary to keep viable coho salmon populations in the Trinity system?

Upper Trinity - Population growth rate – Perhaps it could be clarified that declines in population growth rates due to hatchery-wild mixing would likely not be uniform over time (throughout the timeline of the Proposed Action), but could actually get worse as time progresses (Araki et al. 2008; Fraser 2008).

Lower Trinity – *"Because hatchery fish have lower productivity than wild fish (Araki et al.2009; HSRG 2009), straying of hatchery coho salmon would continue to keep the population growth rate low."*
It is suggested that the conclusion of this sentence be toned down a bit, or at least more carefully worded. Reduced fitness in hatchery-wild hybrids relative to wild fish suggests that population growth rate would be reduced by such mixing, but on the other hand, stocking of more hatchery fish could represent an offset/demographic boost against this fitness loss.

South Fork Trinity River population unit – *"Because hatchery fish have lower productivity than wild fish (Araki et al. 2009; HSRG 2009), straying of hatchery coho salmon would continue to keep the population growth rate low."* See above.

APPENDIX 1: BIBLIOGRAPHY OF MATERIALS PROVIDED FOR REVIEW

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APPENDIX 2: STATEMENT OF WORK FOR DR. DYLAN FRASER

External Independent Peer Review by the Center for Independent Experts

Biological Opinion for the Trinity River Division of the Central Valley Project

Scope of Work and CIE Process: The National Marine Fisheries Service's (NMFS) Office of Science and Technology coordinates and manages a contract to provide external expertise through the Center for Independent Experts (CIE) to conduct impartial and independent peer reviews of NMFS scientific projects. This Statement of Work (SoW) described herein was established by the NMFS Contracting Officer's Technical Representative (COTR) and CIE based on the peer review requirements submitted by NMFS Project Contact. CIE reviewers are selected by the CIE Coordination Team and Steering Committee to conduct the peer review of NMFS science with project specific Terms of Reference (ToRs). Each CIE reviewer shall produce a CIE independent peer review report with specific format and content requirements (**Annex 1**). This SoW describes the work tasks and deliverables of the CIE reviewers for conducting an independent peer review of the following NMFS project.

Project Description: The U.S. Bureau of Reclamation (BOR) proposed to operate the Trinity River Division of the Central Valley Project until 2030. The Project includes facilities to store, divert, and distribute water for irrigation, power generation and fish and wildlife mitigation and protection. The project blocks access to 109 miles of anadromous fish habitat on the Trinity River located upstream of the dam. The amount of water proposed to be diverted from the Trinity River to the Sacramento River equates to approximately 743,243 acre-feet, or 54% of average annual inflow to the Trinity River.

The Trinity River is the largest tributary to the Klamath River, draining approximately 7,690 km^2 in California. The Klamath River system is the second largest river system in California draining approximately 26,000 km^2 in California, and 14,000 km^2 in Oregon. It once supported large anadromous populations of fall and spring run chinook salmon (*Oncorhynchus tshawytscha*), coho salmon (*O. kisutch*), steelhead (*O. mykiss*) as well as Pacific Lamprey *(Lamptera tridentata)*, and green sturgeon (*Acipenser medirostris*) that supported commercial and recreational fisheries, as well as cultural, subsistence, and commercial needs of native tribes throughout the region.

In 1957 construction began on the Trinity River Division of Bureau of Reclamation's Central Valley Project (CVP), which transfers water from the Klamath Basin to the Sacramento Basin. The Division consists of a series of dams, lakes, power plants, a tunnel, and other related facilities. Lewiston Dam, part of the CVP, was constructed in 1963 near Lewiston, California and is now the upper limit of anadromous fish migration on the Trinity River. At times, 90% of the of the Trinity River flow was diverted to the Sacramento Basin, contributing to the decline of chinook salmon and coho salmon. These water withdrawals, which extracted a large portion of Trinity River water, caused severe degradation to fish habitat of the Trinity River. Trinity River Hatchery (TRH), located at the base of Lewiston Dam, was constructed to mitigate for the loss of 109 miles of anadromous fish habitat upstream of the dam. However, the hatchery does not mitigate for habitat altered or lost downstream of the dams. Trinity River Hatchery releases roughly 4.3 million Chinook salmon, 0.5 million coho salmon and 0.8 million steelhead annually.

Out of concern for declines in anadromous fish populations, Congress enacted the Trinity River Fish and Wildlife Restoration Act (P.L. 98-541) in 1984. This act directed the Secretary of the Interior to take actions necessary to restore the fisheries resources of the Trinity River Basin. The Central Valley Project Improvement Act (CVPIA) of 1992 (P.L. 102-575) legislated alterations in the operation of the CVP for the improvement of fish and wildlife habitat and resources.

In December 2000, Interior signed the Record of Decision (ROD) for the Trinity River Mainstem Fishery Restoration Environmental Impact Statement (EIS) and EIR. The ROD, based mainly on the Trinity River Flow Evaluation Study, was the culmination of years of investigations on the Trinity River. The ROD adopted the preferred alternative, a suite of actions that included a variable annual flow regime, mechanical channel rehabilitation, sediment management, watershed restoration, and adaptive management. The EIS/EIR was challenged in Federal District Court. (Westlands Water District, et al. v. United States Dept. of the Interior, 275 F.Supp.2d 1157 (E.D. Cal, 2002)). Initially, the District Court limited increased flows to the Trinity River called for by the ROD until preparation of a supplemental environmental document was completed. On July 13, 2004, the Ninth Circuit reversed that part of the decision, ruling that Reclamation did not need to prepare a supplemental environmental document. (Westlands Water District, et al. v. United States Dept. of the Interior, 376 F.3d 853 (9th Cir. 2004)). Consequently, Reclamation has been and continues to implement the flows described in the Trinity ROD.

This is a controversial federal action with a recent litigious history. The project has large potential implications on the economy of California's Central Valley, coastal communities in California and Oregon, commercial and recreational fisheries in California and Oregon, and tribal and public trust resources. Additionally, the biological opinion will contain new and innovative analyses and assessment models to help quantify hatchery effects on listed coho salmon and the effects of the project on coho salmon habitat.

The Terms of Reference (ToRs) of the peer review are attached in **Annex 2**.

Requirements for CIE Reviewers: Three CIE reviewers shall conduct an impartial and independent peer review in accordance with the SoW and ToRs herein. Each CIE reviewer's duties shall not exceed a maximum of 10 days to complete the work tasks of the peer review described herein. CIE reviewers shall have the expertise, background, and experience to complete an independent peer review in accordance with the SoW and ToRs herein. CIE reviewer expertise shall include hydrology, Pacific salmon hatcheries, and river restoration.

Location of Peer Review: Each CIE reviewer shall conduct a desk review, therefore no travel is required.

Statement of Tasks: Each CIE reviewers shall complete the following tasks in accordance with the SoW and Schedule of Milestones and Deliverables herein.

Prior to the Peer Review: Upon completion of the CIE reviewer selection by the CIE Steering committee, the CIE shall provide the CIE reviewer information (name, affiliation, and contact details) to the COTR, who forwards this information to the NMFS Project Contact no later the date specified in the Schedule of Milestones and Deliverables. The SoW with ToRs is established by the NMFS Project Contract, and CIE is responsible for providing the SoW and ToRs to the CIE reviewers. The NMFS Project Contact is responsible for providing the CIE reviewers with the background documents and reports for the peer review. Any changes to the SoW or ToRs must be made through the COTR prior to the commencement of the peer review.

Pre-review Background Documents: Two weeks before the peer review, the NMFS Project Contact will send by electronic mail or make available at an FTP site the CIE reviewers all necessary background information and reports for the peer review. In the case where the documents need to be mailed, the NMFS Project Contact will consult with the CIE on where to send documents. The CIE reviewers shall read all documents in preparation for the peer review.

1. Trinity River Flow Evaluation Study (300 pages, much of which can be skimmed)
2. Bureau of Reclamation Biological Assessment (70 pages)
3. Coho salmon viability documents (100 pages)
4. Hatchery background information to be determined (50 pages)

This list of pre-review documents may be updated up to two weeks before the peer review. **Any delays in submission of pre-review documents or reports for the CIE peer review will result in delays with the CIE peer review process, including a SoW modification to the schedule of milestones and deliverables.** Furthermore, the CIE reviewers are responsible only for the pre-review documents that are delivered to the reviewer in accordance to the SoW scheduled deadlines specified herein.

Peer Review: Each CIE reviewers shall conduct the independent peer review in accordance with the SoW and ToRs. **Modifications to the SoW and ToRs can not be made during the peer review, and any SoW or ToRs modifications prior to the peer review shall be approved by the COTR and CIE Lead Coordinator.** The CIE Lead Coordinator can contact the Project Contact to confirm any peer review arrangements.

Contract Deliverables - Independent CIE Peer Review Reports: Each CIE reviewer shall complete an independent peer review report in accordance with the SoW. Each CIE reviewer shall complete the independent peer review according to required format and content as described in Annex 1. Each CIE reviewer shall complete the independent peer review addressing each ToR as described in Annex 2.

Specific Tasks for CIE Reviewers: The following chronological list of tasks shall be completed by each CIE reviewer in a timely manner as specified in the **Schedule of Milestones and Deliverables**.

1) Conduct necessary pre-review preparations, including the review of background material and reports provided by the NMFS Project Contact in advance of the peer review;

2) Complete independent peer review addressing each ToRs (Annex 2).
3) No later than REPORT SUBMISSION DATE, each CIE reviewer shall submit an independent peer review report addressed to the "Center for Independent Experts," and sent to Mr. Manoj Shivlani, CIE Lead Coordinator, via email to shivlanim@bellsouth.net, and Dr. David Die, CIE Regional Coordinator, via email to ddie@rsmas.miami.edu. Each CIE report shall be written using the format and content requirements specified in Annex 1, and address each ToR in Annex 2;
4) CIE reviewers shall address changes as required by the CIE review in accordance with the schedule of milestones and deliverables.

Schedule of Milestones and Deliverables: CIE shall complete the tasks and deliverables described in this SoW in accordance with the following schedule.

21 August 2009	CIE sends reviewer contact information to the COTR, who then sends this to the NMFS Project Contact
21 August	NMFS Project Contact sends the CIE Reviewers the pre-review documents
21 August – 3 September	Each reviewer participates and conducts an independent peer review
4 September	CIE reviewers submit draft CIE independent peer review reports to the CIE Lead Coordinator and CIE Regional Coordinator
18 September	CIE submits CIE independent peer review reports to the COTR
25 September 2009	The COTR distributes the final CIE reports to the NMFS Project Contact and regional Center Director

Modifications to the Statement of Work: Requests to modify this SoW must be made through the Contracting Officer's Technical Representative (COTR) who submits the modification for approval to the Contracting Officer at least 15 working days prior to making any permanent substitutions. The Contracting Officer will notify the CIE within 10 working days after receipt of all required information of the decision on substitutions. The COTR can approve changes to the milestone dates, list of pre-review documents, and Terms of Reference (ToR) of the SoW as long as the role and ability of the CIE reviewers to complete the SoW deliverable in accordance with the ToRs and deliverable schedule are not adversely impacted. The SoW and ToRs cannot be changed once the peer review has begun.

Acceptance of Deliverables: Upon review and acceptance of the CIE independent peer review reports by the CIE Lead Coordinator, Regional Coordinator, and Steering Committee, these reports shall be sent to the COTR for final approval as contract deliverables based on compliance with the SoW. As specified in the Schedule of Milestones and Deliverables, the CIE shall send via e-mail the contract deliverables (the CIE independent peer review reports) to the COTR (William Michaels, via William.Michaels@noaa.gov).

Applicable Performance Standards: The contract is successfully completed when the COTR provides final approval of the contract deliverables. The acceptance of the contract deliverables shall be based on three performance standards: (1) each CIE report shall have the format and content in accordance with Annex 1, (2) each CIE report shall address each ToR as specified in Annex 2, (3) the CIE reports shall be delivered in a timely manner as specified in the schedule of milestones and deliverables.

Distribution of Approved Deliverables: Upon notification of acceptance by the COTR, the CIE Lead Coordinator shall send via e-mail the final CIE reports in *.PDF format to the COTR. The COTR will distribute the approved CIE reports to the NMFS Project Contact and regional Center Director.

Key Personnel:

William Michaels, Contracting Officer's Technical Representative (COTR)
NMFS Office of Science and Technology
1315 East West Hwy, SSMC3, F/ST4, Silver Spring, MD 20910
William.Michaels@noaa.gov Phone: 301-713-2363 ext 136

Manoj Shivlani, CIE Lead Coordinator
Northern Taiga Ventures, Inc.
10600 SW 131st Court, Miami, FL 33186
shivlanim@bellsouth.net Phone: 305-383-4229

NMFS Project Contact:

Seth Naman
1655 Heindon Rd., Arcata, CA 95521
seth.naman@noaa.gov Phone: 707-825-5180

Irma Lagomarsino
NMFS, Southwest Region, 1655 Heindon Road, Arcata, CA 95521
Irma.Lagomarsino@noaa.gov Phone: 707-825-5160

Annex 1: Format and Contents of CIE Independent Peer Review Report

1. The CIE independent report shall be prefaced with an Executive Summary providing a concise summary of the findings and recommendations.

2. The main body of the reviewer report shall consist of a Background, Summary of Findings for each ToR, Conclusions and Recommendations in accordance with the ToRs.

3. The reviewer report shall include as separate appendices as follows:

   Appendix 1: Bibliography of materials provided for review
   Appendix 2: A copy of the CIE Statement of Work

Annex 2: Terms of Reference for the Peer Review

Biological Opinion for the Trinity River Division of the Central Valley Project

(i) Does the draft biological opinion incorporate and utilize the latest scientific information on climate change into the analysis of impacts from the project through the year 2030?
(ii) Does the draft biological opinion incorporate and utilize the latest scientific information on the effects of hatchery fish on listed fish?
(iii)Does the draft biological opinion utilize the concepts of viable salmonid populations and the population structure of listed coho salmon?
(iv)Does the draft biological opinion consider the effects of the project on the habitat of listed coho salmon?
(v) Does the biological opinion represent the best scientific information available?